A Study of Temporal Variability of Atmospheric Total Gaseous Mercury Concentrations in Windsor, Ontario, Canada

Xiaohong (Iris) Xu, Umme Akhtar, Kyle Clark, Xiaobin Wang
University of Windsor, Windsor, Ontario Canada

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Outline

- Background
- Objectives
- Method
- Results
- Summary & future work

Air Quality in Windsor, Ontario, Canada

- Industrial sources:
  - Automotive capital of US & Canada
  - Other sectors: power generation and chemical facilities



- Mobile sources:
  - Ambassador Bridge: busiest international crossing in North America
  - 25% of goods by trade values
  - 10,000 heavy duty trucks/day
  - 4,000 cars/day

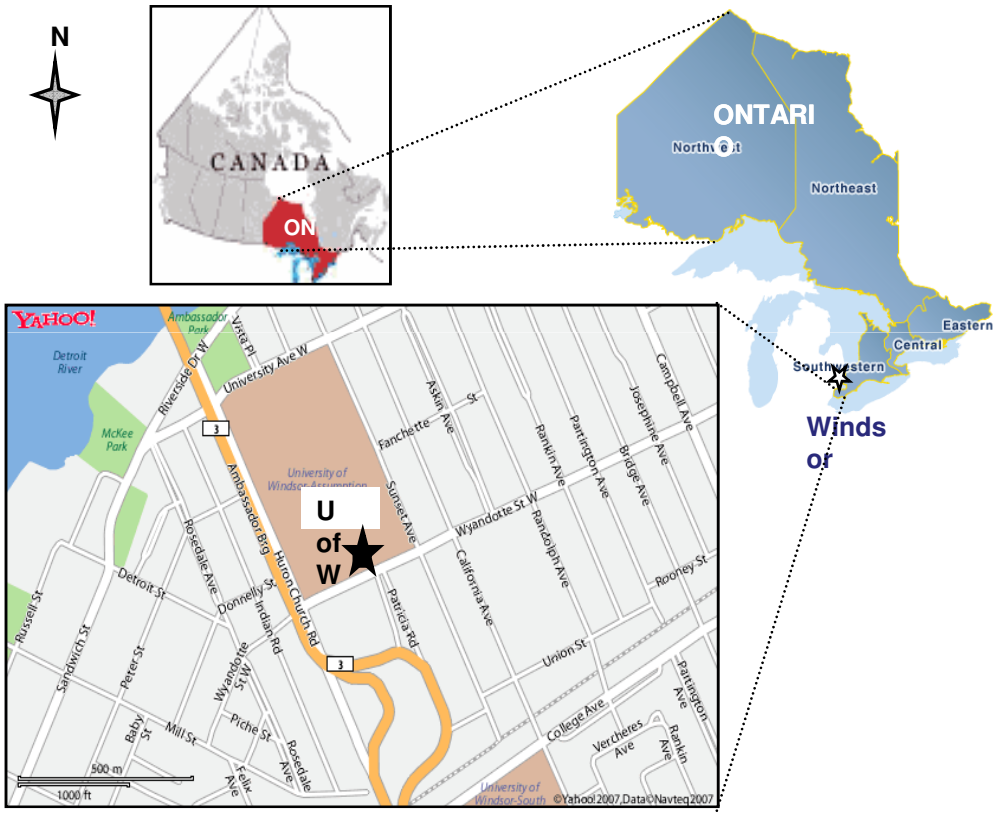


Objectives

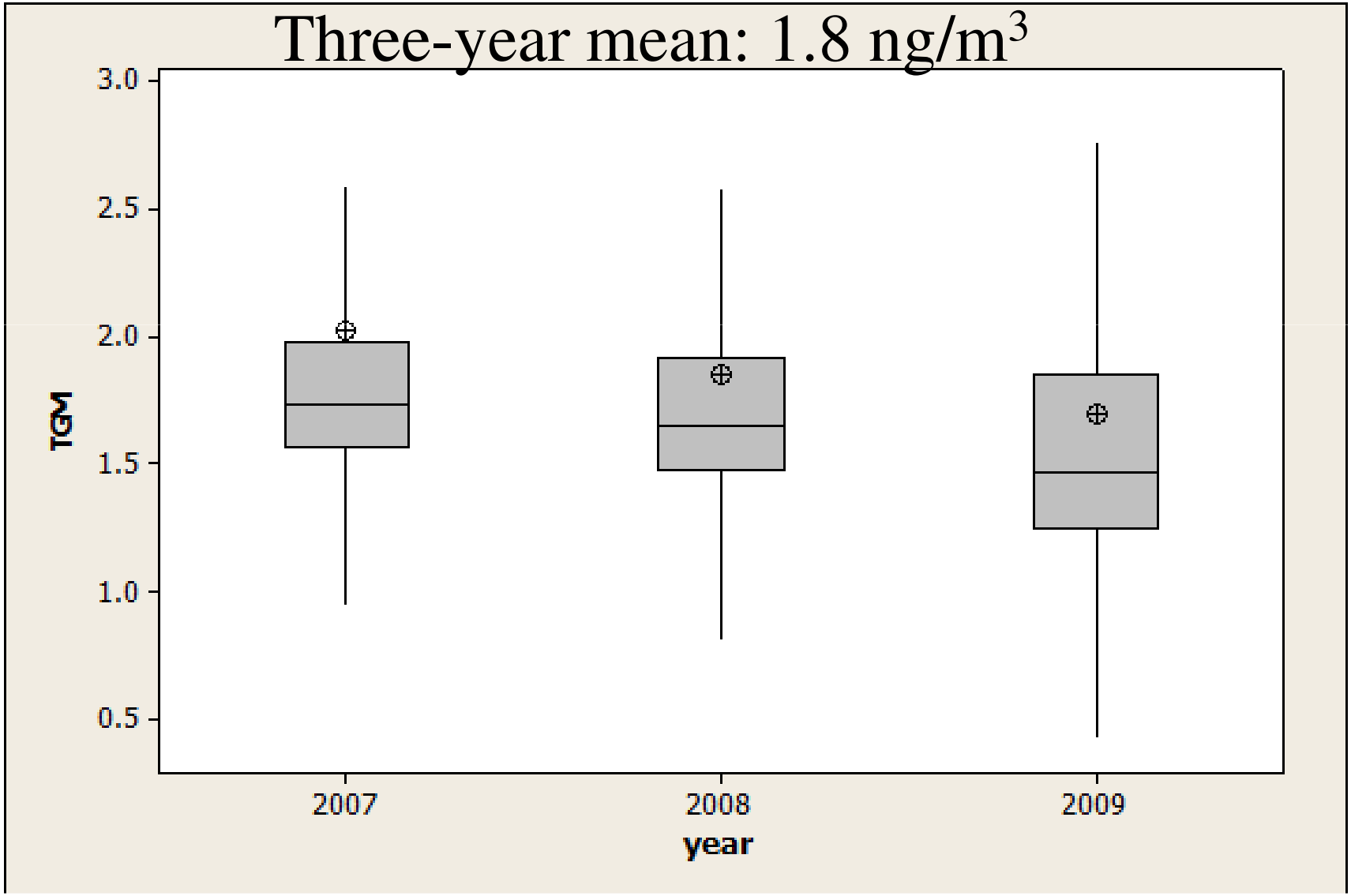
- To investigate
  - temporal variability: diurnal, day-of-week, seasonal, and inter-annual
  - relationship between TGM and other pollutants
  - relationship between TGM and weather conditions
  - effect of variability in TGM and other parameters
  - effect of “outliers”

Monitor Site & Instrumentation

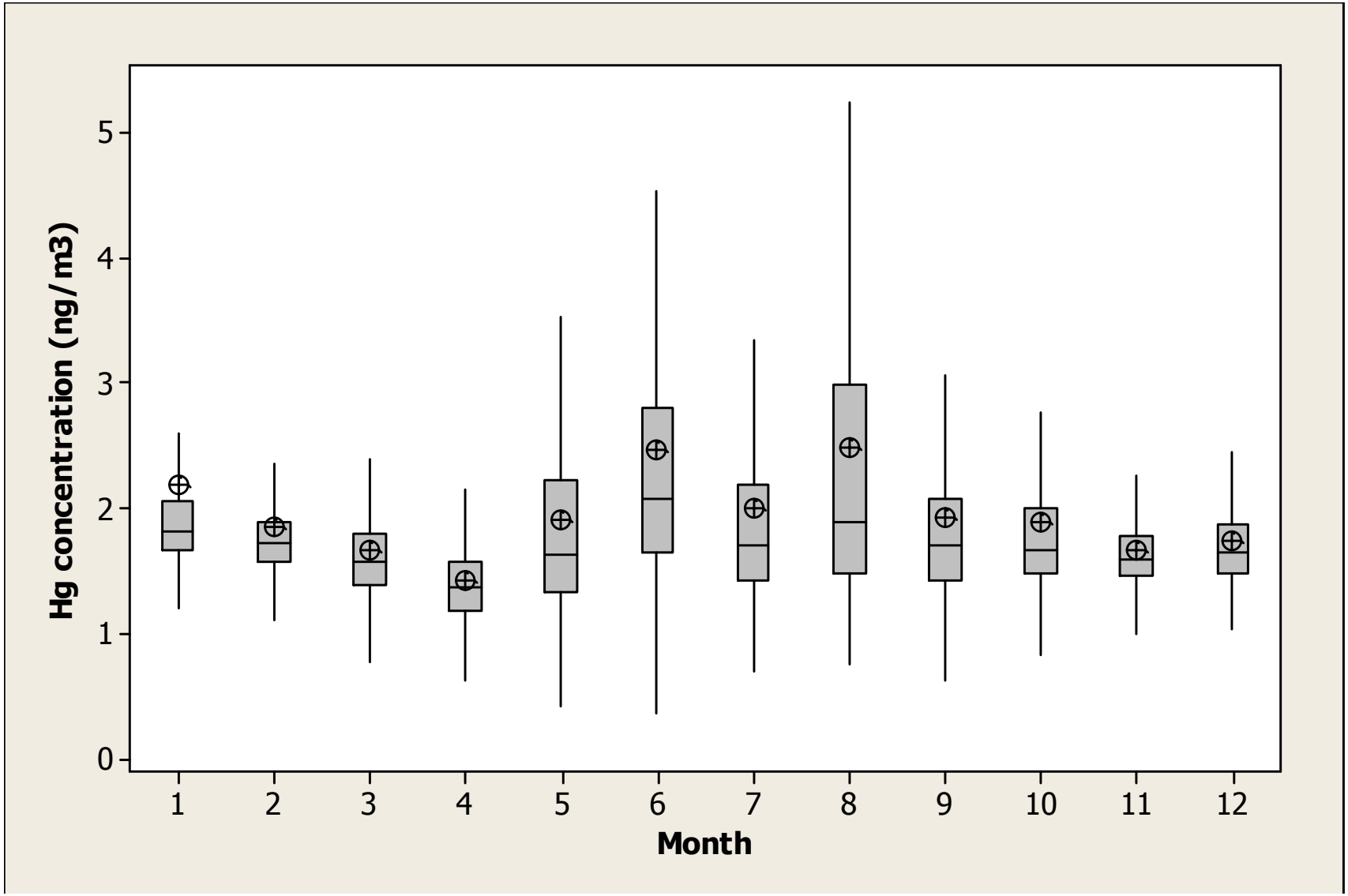
- TGM
  - ✓ University of Windsor campus
  - ✓ Near the entrance/exit of the Ambassador Bridge
  - ✓ Tekran 2537A
- Weather data: Windsor Airport (10 km)
- Other air pollutants: Windsor Downtown Air Quality Station (2 km)
- Study period: 2007-2011



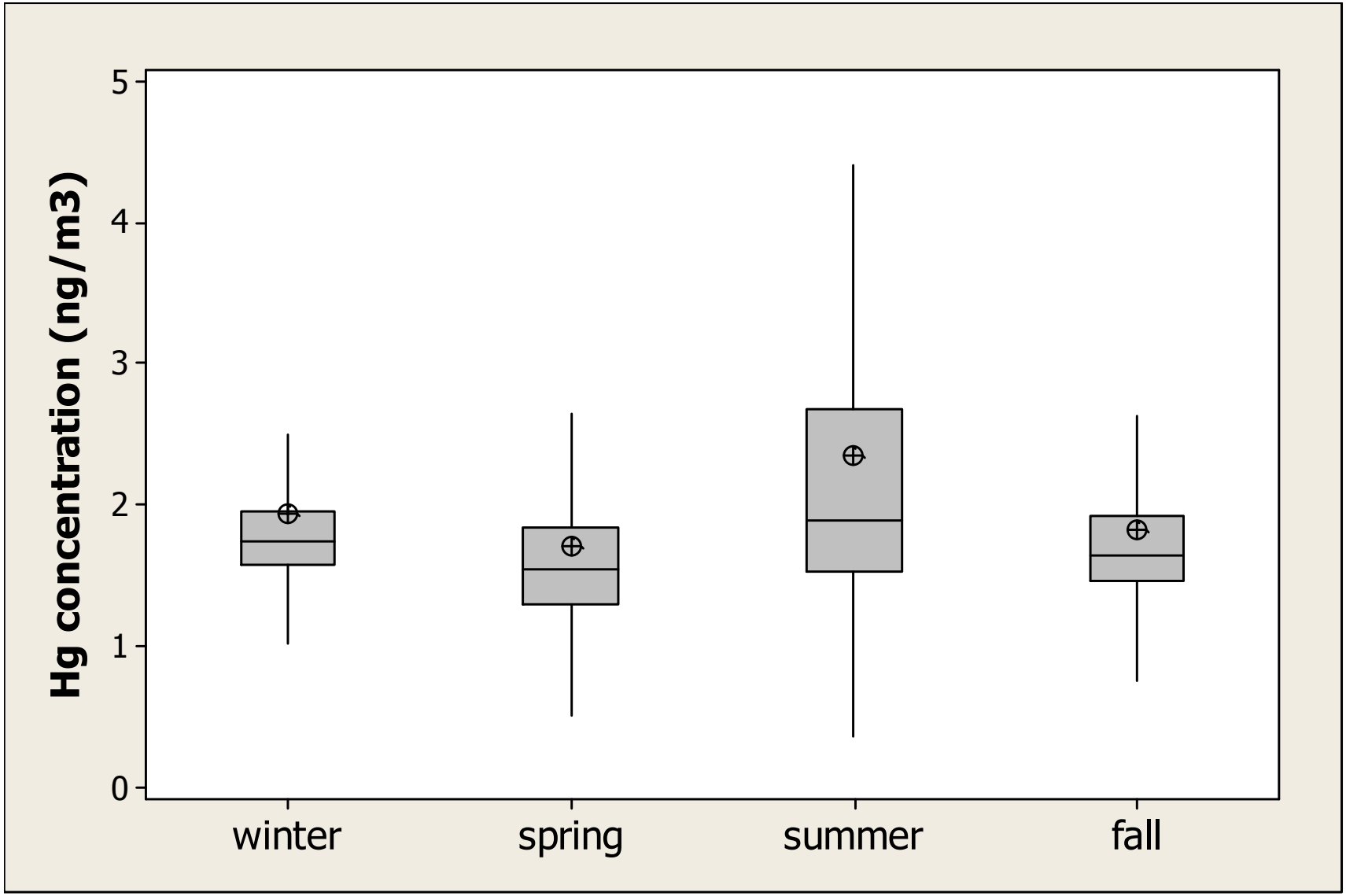
Annual TGM


Three-year mean: 1.8 ng/m3
3.0
2.5
2.0
1.5
1.0
0.5
TGM
2007
2008
2009
year

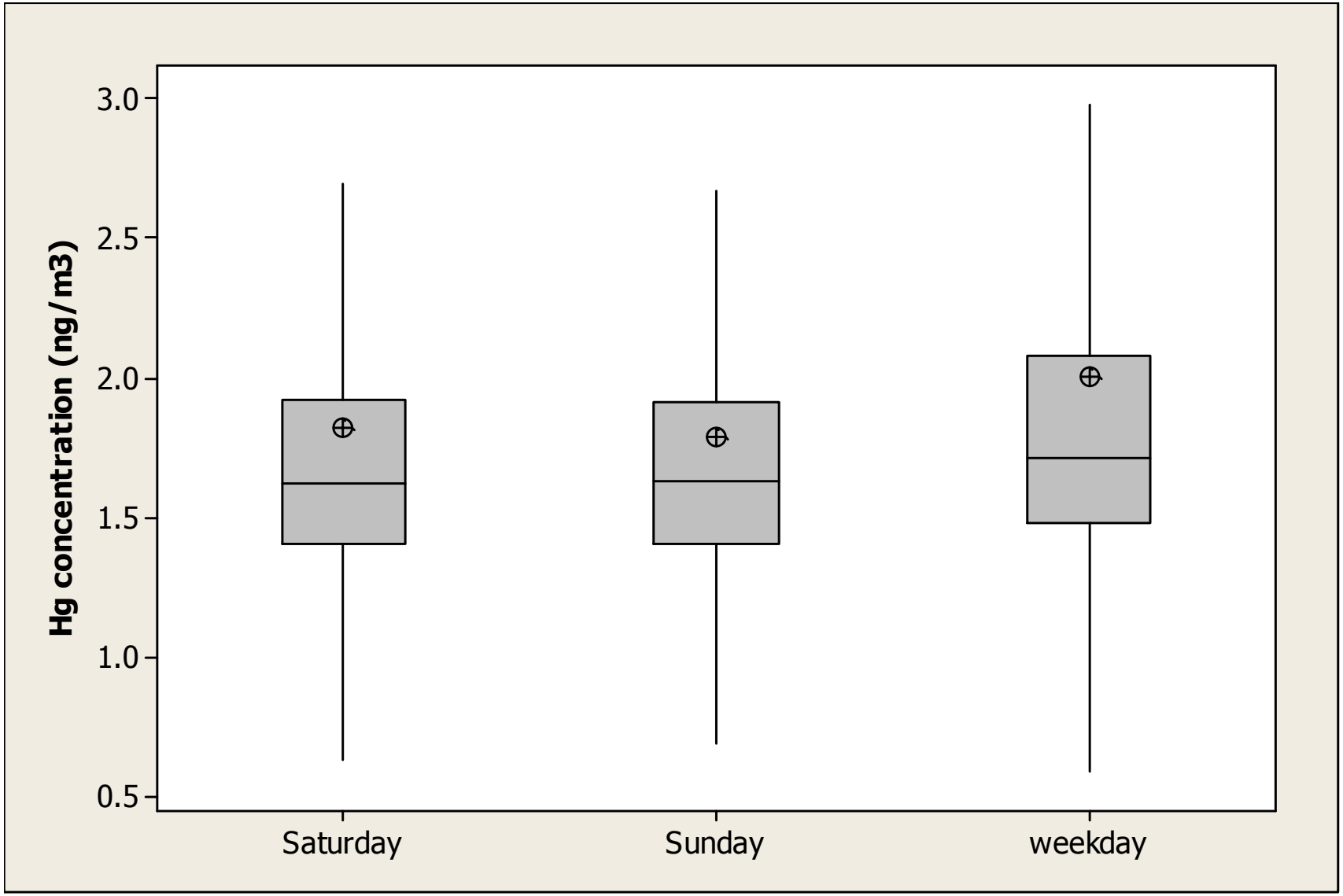
Monthly TGM



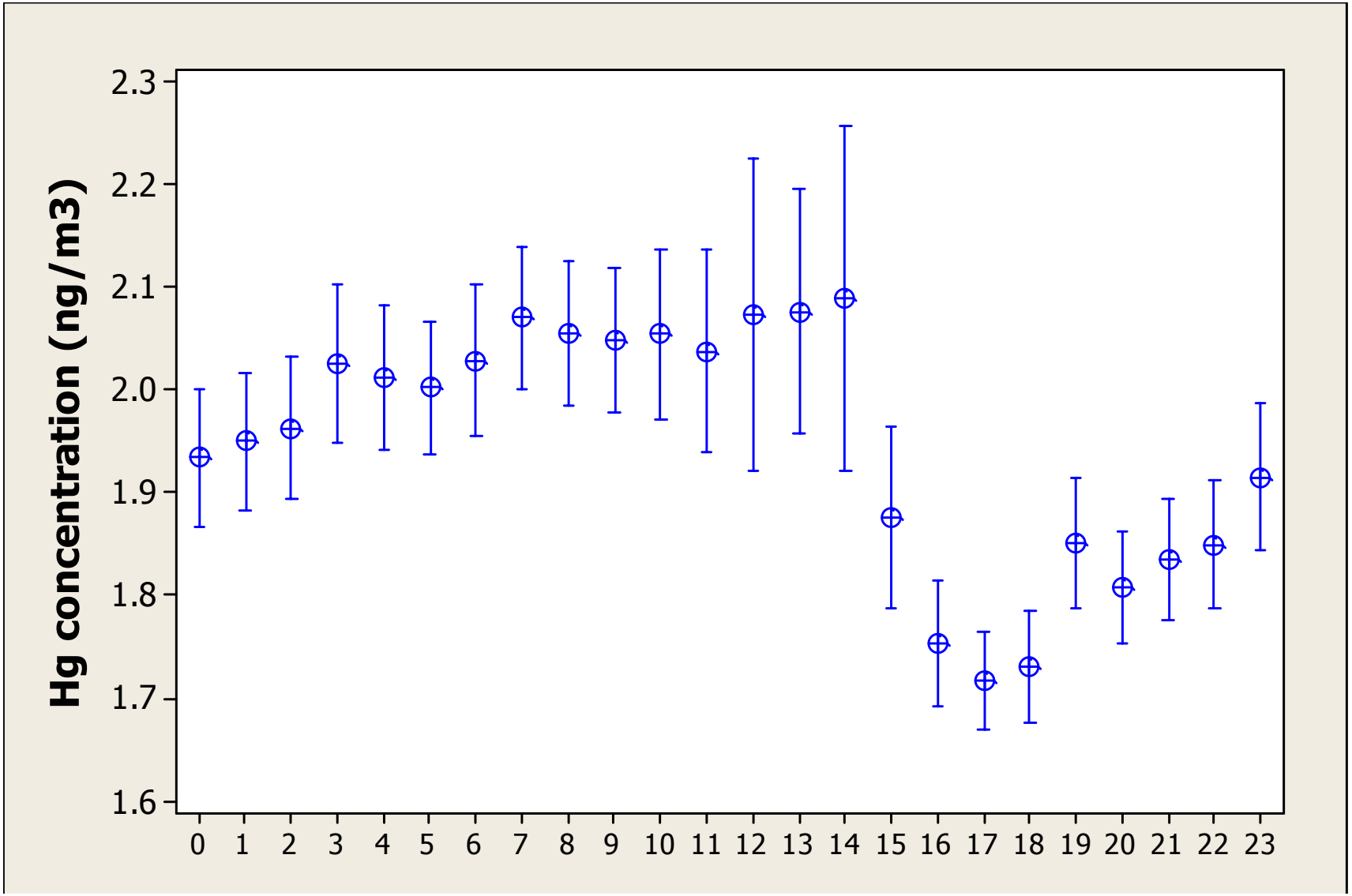
Seasonal TGM



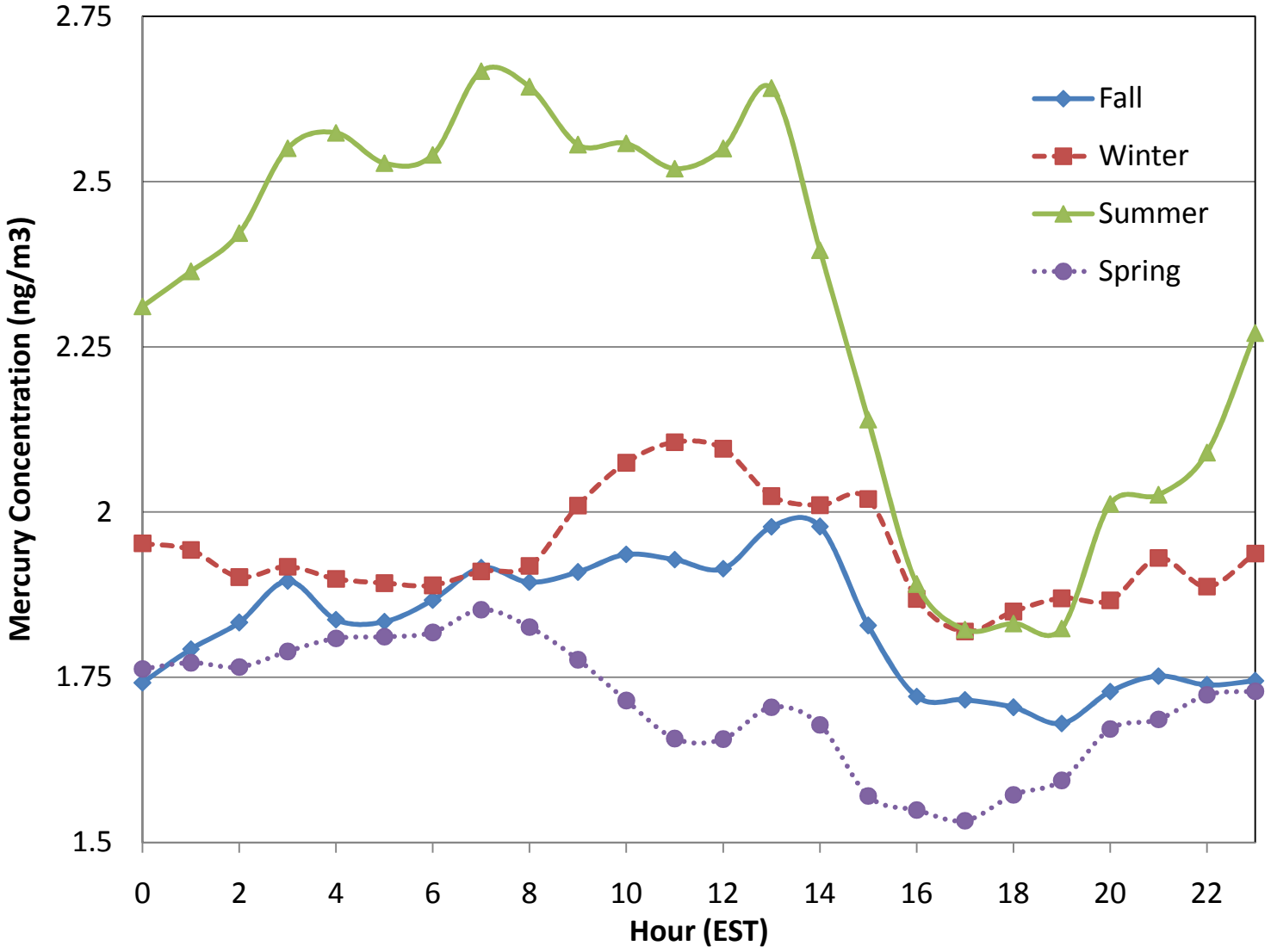
Day-of-week TGM



Diurnal TGM


Hg concentration (ng/m3)
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Diurnal TGM by Season



Temporal Variability – ANOVA

GLM: 2007-2009 data & TGM as dependent variable

Parameter	R^2 (%)
Season	2.65
Year	0.96
Hour-of-day	0.89
Day-of-week	0.60
All of above	5.4

Relationship with Other Parameters

Stepwise regression: TGM as dependent variable

Parameter	R^2 (adj)
NOx	2.1
+temperature	3.0
+O_3	3.4
+pressure	3.7

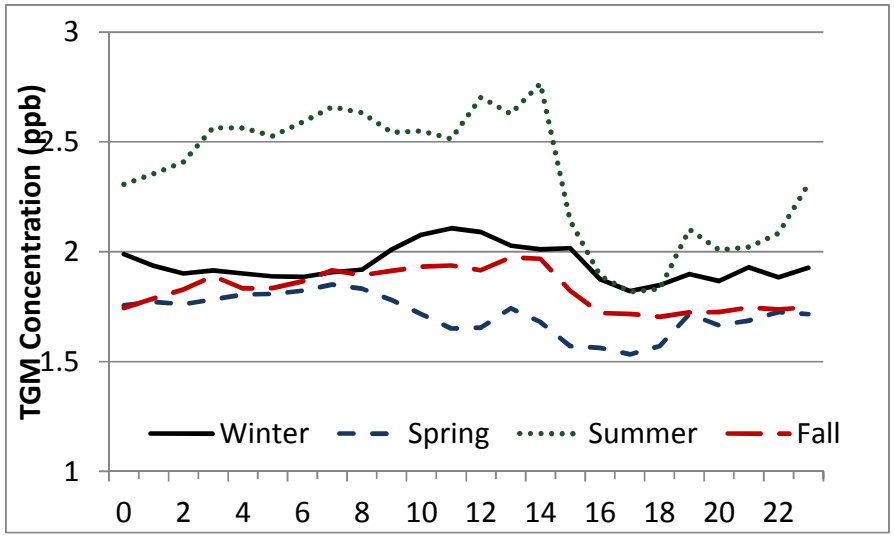
Correlation with Other Parameters

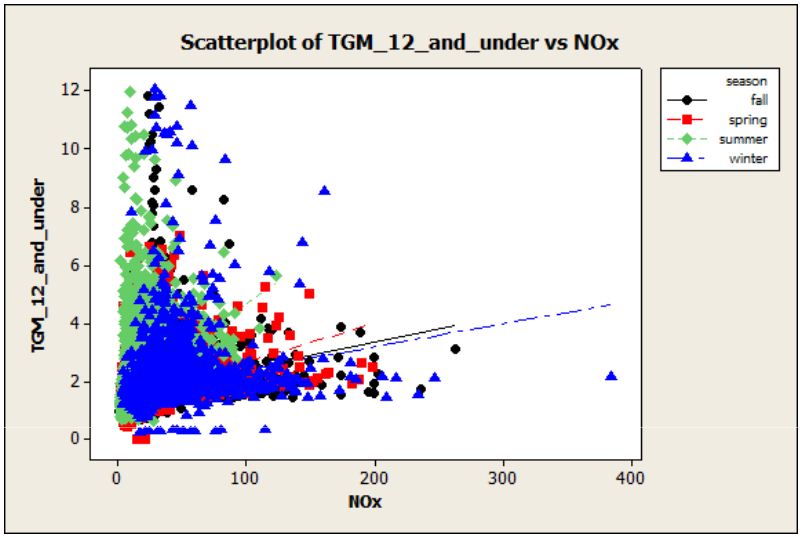
Pearson: all significant at $p < 0.05$ except shaded cells

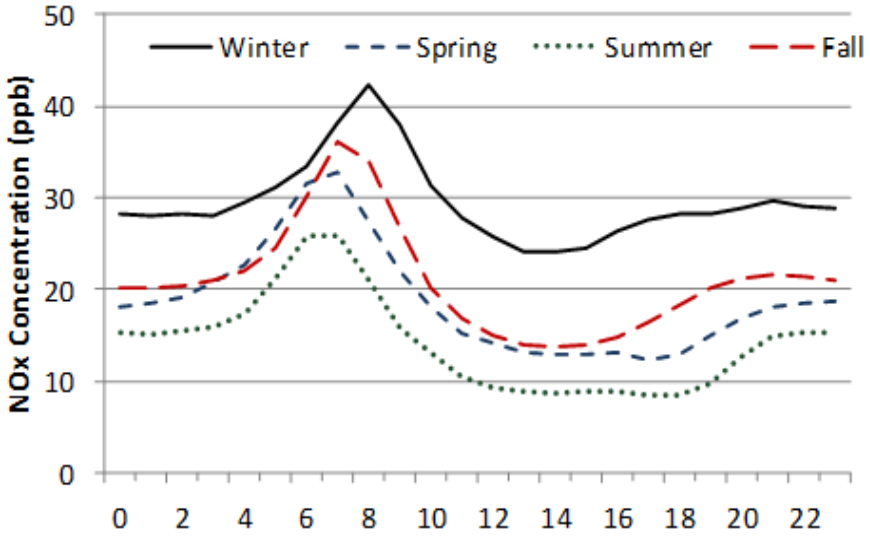
Parameter	2007–2011 (N = 23,467)	Winter (N = 5,303)	Spring (N = 6,041)	Summer (N = 5,512)	Fall (N = 6,612)
SO_2	−0.008	0.046	0.031	−0.045	−0.039
NO	0.083	0.084	0.188	0.112	0.162
NO_2	0.106	0.117	0.288	0.130	0.146
NO_x	0.105	0.109	0.269	0.142	0.177
CO	0.100	0.105	0.318	0.178	0.190
O_3	−0.068	−0.090	−0.227	−0.106	−0.092
$PM_{2.5}$	0.074	0.067	0.248	−0.021	0.053
Temperature	0.090	−0.084	0.144	−0.042	0.112
Relative humidity	0.078	−0.007	0.251	0.108	0.006
Wind speed	−0.083	0.025	−0.216	−0.051	−0.068
Pressure	−0.073	−0.022	−0.115	−0.076	−0.063

- +tv with NO, NO_2, NOx, CO and PM2.5: common sources
- –tv with O_3: photo-chemistry
- –tv with wind speed and pressure: dispersion and mixing
- A lack of strong correlations: all data and by season
- Similar results with Spearman

TGM and NOx



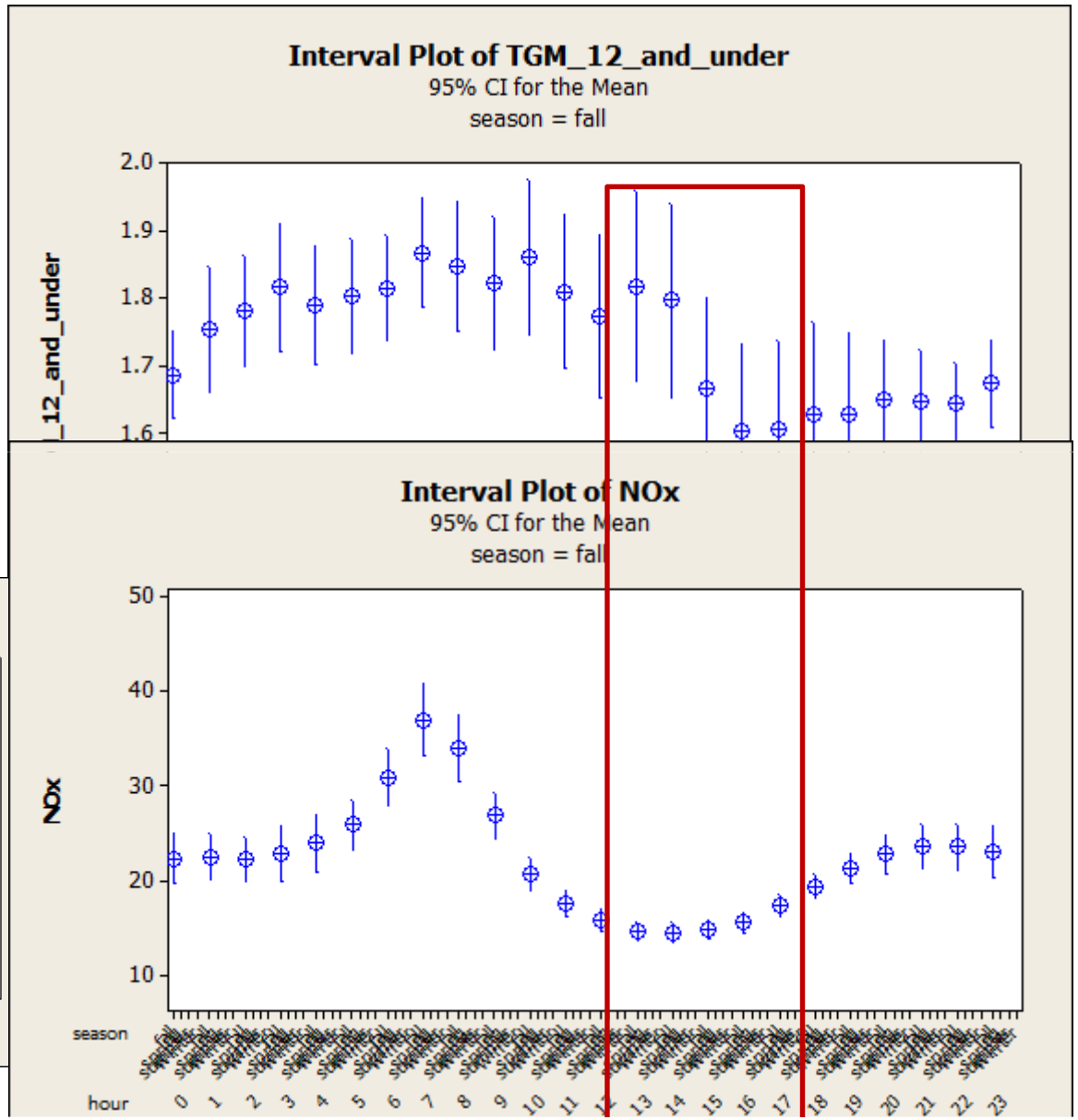


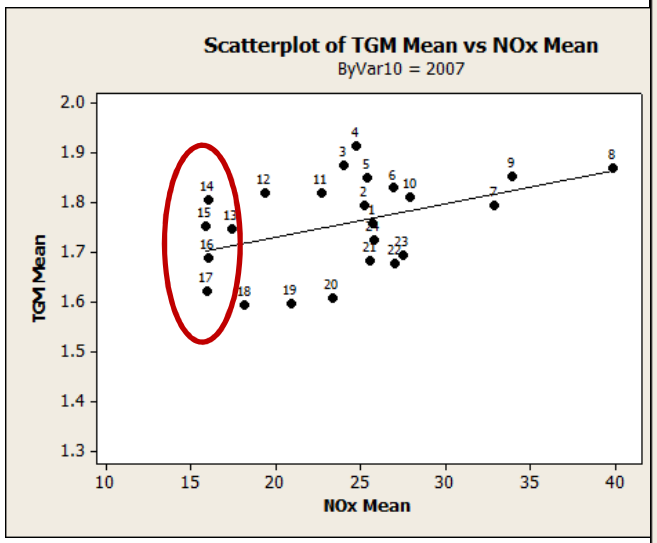


- Not all by out of phase in hour-of-day
- Large variability in both compounds
- Low TGM when NOx high

TGM & NOx in Fall

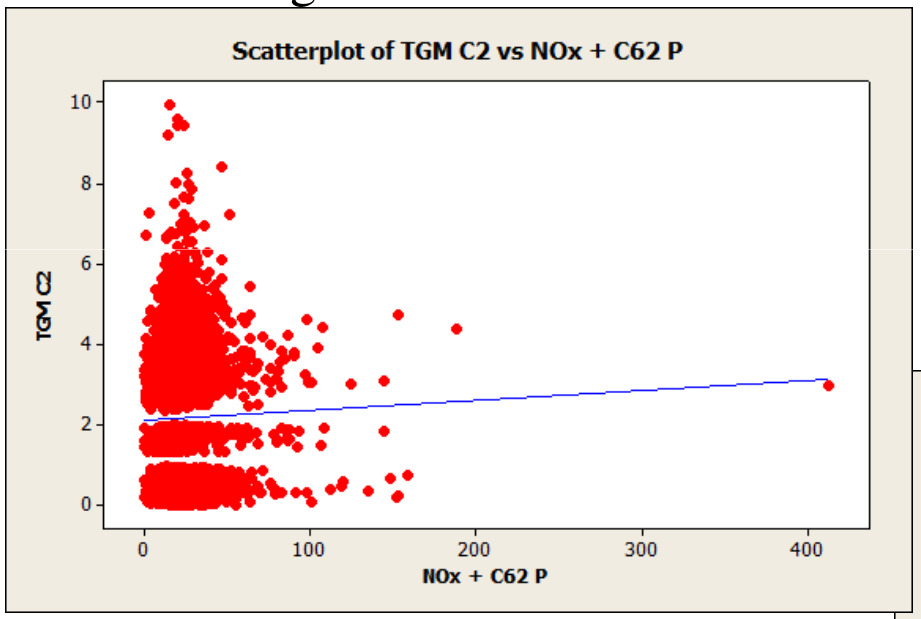
- Similar trends
- Afternoon low NOx but relatively high TGM with grater variability

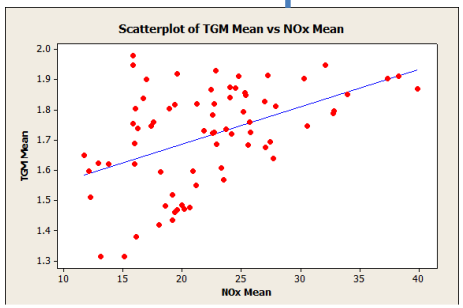


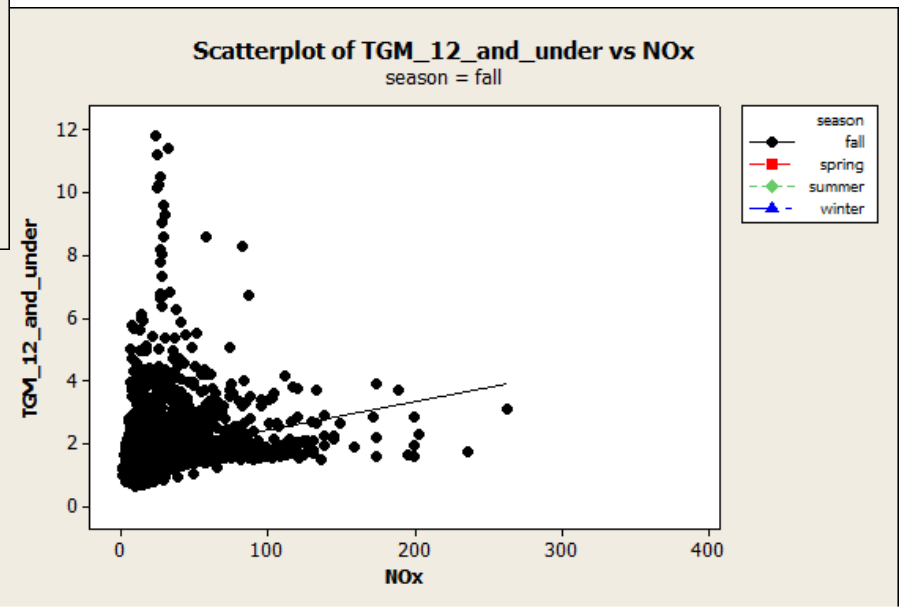


TGM & NOx in Fall

- Get hour-of-day concentrations: TGM and NOx in fall
- Add noise to recreate hourly concentrations
- Noise: log-normal distribution with zero mean: based on hour-of-day SD







Effect of Outliers

- Full model (GLM), all significant at $p<0.05$
- Season, year, hour of day, day-of-week
- Plus NOx, SO_2, O_3, temperature, relative humidity, wind speed
- Original data: R^2 =21%
- Remove hourly TGM >12 ng/m^3, R^2=31%

Summary

- Annual
  - ✓gradual decrease from 2007 – 2009
- Seasonal
  - ✓higher in summer and winter compared to fall and spring
  - ✓variability high in summer and low in winter
  - ✓similar to some urban sites with industrial impact
- Day-of-week
  - ✓10% higher on weekdays than weekends

Summary

Diurnal

- Similar trends in winter and fall
- Summer – steep decrease right after noon: strong oxidation & strong mixing
- Spring – early depletion: oxidation
- Similar to some urban sites with industrial impact

Summary

- Temporal factors: season, year, hour of day, day-of-week
- A lack of strong correlation with other pollutants and meteorological data
- High TGM when other pollutants were low
- Clear trend with meteorological parameters but great scattering especially in summer and winter
- Overall low % variance explained by temporal factors and environmental conditions
  - Large variability in TGM and other factors
  - Strong influence by a few high TGM events

Future Work

- Expend recreation of hourly data using hour-of-day mean and SD to other pollutants /meteorological data in other seasons
- Further investigate the effect of outliers: especially SO_2 (right skewed)

Acknowledgements

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Conclusions

- TGM concentrations close to other urban sites in the region
- Higher concentrations in summer and winter
- Seasonal and diurnal variability influenced by environmental conditions, such as atmospheric mixing, photochemistry (oxidation), surface emissions
- Pollution rose suggests areas of potential regional sources in east to southwest of Windsor, with seasonal shift

Monitoring Site

